(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 483 372 A1**

(12) **EUROPEAN PATENT APPLICATION published in accordance with Art. 158(3) EPC**

(21) Application number: **91909093.6**

(51) Int. Cl.5: **H02K 1/27**

(22) Date of filing: **15.05.91**

(86) International application number:
PCT/JP91/00640

(87) International publication number:
WO 91/18439 (28.11.91 91/27)

(30) Priority: **15.05.90 JP 122893/90**

(43) Date of publication of application:
06.05.92 Bulletin 92/19

(84) Designated Contracting States:
DE IT

(71) Applicant: **FANUC LTD.**
3580, Shibokusa Aza-Komanba, Oshino-mura
Minamitsuru-gun, Yamanashi 401-05(JP)

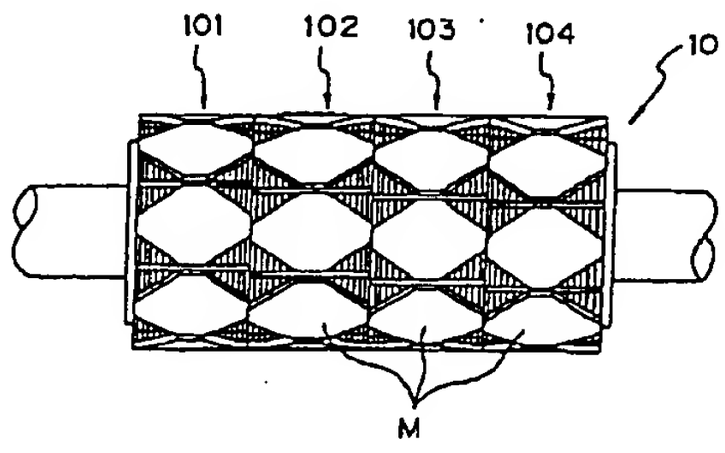
(72) Inventor: **UCHIDA, Hiroyuki, Fanuc Mansion Harimomi 7-107**
3539-1, Shibokusa Oshino-mura
Minamitsuru-gun
Yamanashi 401-05(JP)
Inventor: **YAMAMOTO, Tomonaga, Fanuc Dai-3 Vira-karamatsu**
3527-1, Shibokusa Oshino-mura
Minamitsuru-gun
Yamanashi 401-05(JP)
Inventor: **OKAMOTO, Takashi, Fanuc Dai-3 Vira-karamatsu**
3527-1, Shibokusa Oshino-mura
Minamitsuru-gun
Yamanashi401-05(JP)

(74) Representative: **Otte, Peter, Dipl.-Ing.**
Tiroler Strasse 15
W-7250 Leonberg(DE)

(54) **STRUCTURE OF ROTOR OF SYNCHRONOUS MOTOR.**

(57) A rotor (10) is divided into 2^n rotor elements (101, 102, 103, 104) to eliminate n kinds or the component (A, B) of the torque ripple of a synchronous motor. In order to eliminate the first component (A) of the torque ripple, the two rotor elements of each of 2^{n-1} rotor element pairs (101, 102; 103, 104) are shifted from each other by an angle corresponding to the half of the wavelength (λ) of the first component. In order to eliminate the second component (B), the 2^{n-1} rotor element pairs are divided into 2^{n-2} rotor element groups, each of which comprises the two pairs that are shifted from each other by an angle corresponding to the half of the wavelength (γ) of the second component. The shifting is repeated until the n-th torque ripple component is eliminated, thus constructing a rotor.

Fig. 1



EP 0 483 372 A1

Namely, the rotor element 102 at the second stage is circumferentially shifted from the rotor element 101 at the first stage by a physical angle corresponding to a half of the wavelength λ, and the rotor element 104 at the fourth stage is circumferentially shifted from the rotor element 103 at the third stage by the same physical angle as the above-mentioned angle. As shown in Fig. 2, the torque ripples A1 and B1 appear in an output torque exerted from the rotor 10,and the torque ripples A2 and B2 appear in the output torque exerted from the rotor. It will be understood from the illustration of Fig. 2 that, since the latter torque ripples A2 and B2 have a displacement "λ/2" with respect to the former torque ripples A1 and B1, the torque ripple components A1 and A2 cancel one another out while the torque ripple components B1 and B2 having the wavelength γ are superimposed on one another to generate a different torque ripple B12, the wavelength of which is the same as that "γ" of the torque ripples B1 and B2, but the width of which is different from the torque ripple B1 or B2.

Further, a like canceling and superimposing of the torque ripple components of the output torque from the rotor 10 occurs with respect to the third and fourth stage rotor elements 103 and 104, as shown in Fig. 2. Namely, the torque ripple components A3 and A4 having a displacement "λ/2" cancel one another out, and the torque ripple components B3 and B4 are superimposed on one another to generate a different torque ripple component B34 having the same wavelength γ and width as those of the above-mentioned torque ripple component B12. Accordingly, when the first pair of rotor elements 101 and 102 and the second pair of rotor elements 103 and 104 are arranged to be circumferentially shifted from one another by a physical angle corresponding to a half of the wavelength γ of the torque ripple components B12 and B34, these torque ripple components B12 and B34 can cancel one another out, and consequently, two kinds of cyclic torque ripple components A and B can be completely removed from the output torque of the rotor.

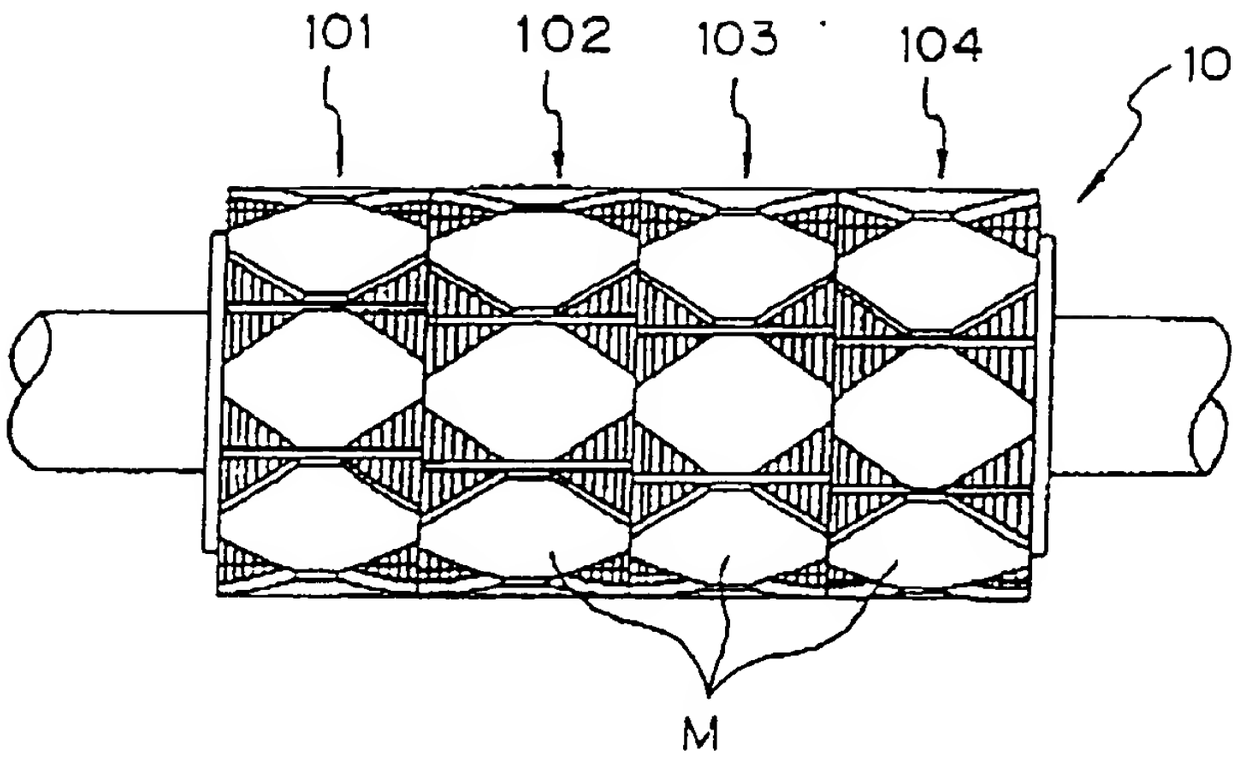
Referring now to Fig. 3, another case is shown wherein three different torque ripple components A (the wavelength: λ), B (the wavelength: γ), and C (the wavelength: δ) contained in an output torque exerted from an electric synchronous motor are cancelled by a permanent-magnet included rotor structure of a synchronous motor according to a different embodiment of the present invention.

In this embodiment, the rotor is constructed by 2^3 equal rotor elements axially arranged side by side, in the same manner as in the embodiment of Fig. 1.

Similar to the embodiment of Fig. 2, the rotor of this embodiment has an arrangement such that first and second stage rotor elements constitute a first pair of rotor elements, the third and fourth stage rotor elements constitute a second pair of rotor elements, the fifth and sixth stage rotor elements constitute a third pair of rotor elements, and the seventh and eighth stage rotor elements constitute a fourth pair of rotor elements, and that the two rotor elements of each of the first through fourth pair of rotor elements are arranged to be circumferentially shifted around the axis of the rotor by a physical angle corresponding to "λ/2" so that cyclic torque ripple components A1 and A2, A3 and A4, A5 and A6, and A7 and A8 cancel one another out. Nevertheless, cyclic torque ripple components B12 and C12 having the wavelengths γ and δ still remain in an output torque exerted by the first pair of rotor elements of the rotor. Also, cyclic torque ripple components B34 and C34, B56 and C56, and B78 and C78 having the wavelengths γ and δ, respectively, remain in an output torque exerted by the second through fourth pairs of rotor elements of the rotor. At this stage, since the first pair of rotor elements including the first and second stage rotor elements and the second pair of rotor elements including the third and fourth stage rotor elements are circumferentially shifted around the axis of the rotor by a physical angle corresponding to a half of the wavelength "γ", i.e., γ/2, the torque ripple components B12 and B34 cancel one another out. Similarly, since the third pair of rotor elements including the fifth and sixth stage rotor elements and the fourth pair of rotor elements including the seventh and eighth stage rotor elements are circumferentially shifted around the axis of the rotor by the same physical angle as the above-mentioned angle "λ/2", the torque ripple components B56 and B78 having the wavelength λ cancel one another out. When the torque ripple component B is canceled, the cyclic torque ripple component C, i.e., the components C1234 and C5678 still remain in an output torque exerted by the rotor. At this stage, as a first section of rotor elements of the rotor including the first and second pairs of rotor elements, i.e., the first through fourth stage rotor elements and a second section of rotor elements of the rotor including the third and fourth pairs of rotor elements, i.e., fifth through eight stage rotor elements are circumferentially mutually shifted around the axis of the rotor by a physical angle corresponding to a half of the wavelength δ, i.e., δ/2, of the torque ripple component C, the torque ripple components C1234 and C5678 cancel one another out. Accordingly, all of the three kinds of torque ripples A, B and C appearing in the output torque exerted by the rotor of this embodiment can be cancelled.

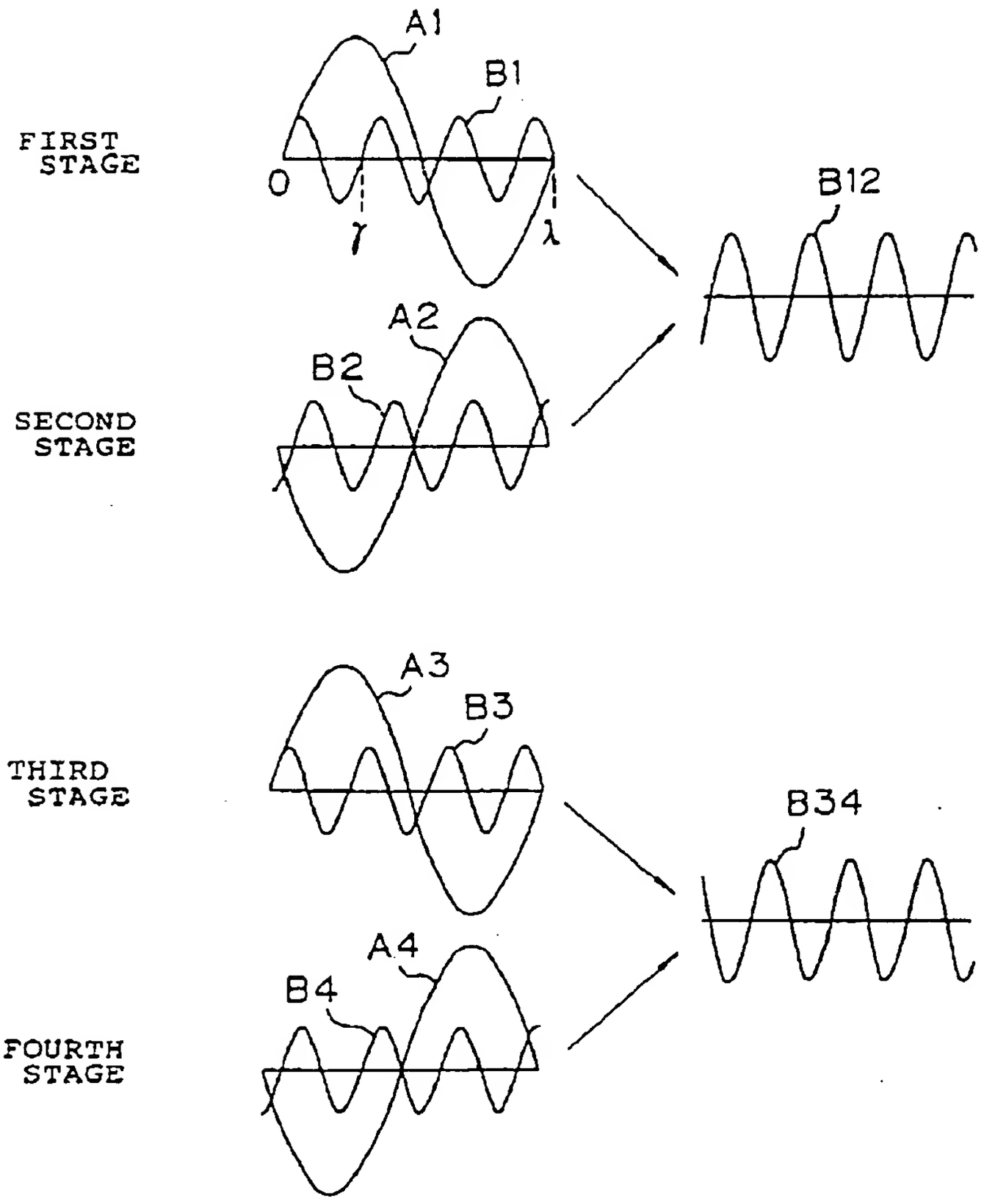
Printed from Mimosa 04/09/17 09:13:32 Page: 3

Fig. 1



Printed from Mimosa 04/09/17 09:13:33 Page: 5

Fig. 2



Printed from Mimosa 04/09/17 09:13:34 Page: 6